Proposal Short Title: The Hg-Mn Stars Mu Leporis and Upsilon Herculis
NASA Grant I.D.: NAG 5-1405
Funding Period: 8/15/90 thru 10/14/91
IUE Program I.D.: APMSR
Principal Investigator: Dr. Scott W. Roby
Co-Investigator: Dr. Saul J. Adelman
P.I.'s Institution: SUNY College at Oswego
(Roby is currently on leave at University of Delaware)
SUNY Oswego Grant I.D.: PN 84330 Acct. 228-0309A
No. of 8-hour shifts used: US2: 4
Number of Targets: 4; Number of Spectra: 45

3P

FINAL REPORT

Multiple IUE observations of the Hg-Mn stars Mu Leporis and Upsilon Herculis were successfully carried out over four US2 shifts (2 in November, 1990 and 2 in January, 1991).

As IUE detectors have limited dynamic ranges, one must take high dispersion images with each camera at several exposure times to achieve acceptable exposure levels over the entire range of the spectrograph for most stars. Leckrone & Adelman (1989) found that coadding several exposures of equal density taken at various positions in the large aperture reduces both "fixed pattern" (FPN) and random (RN) noise. The S/N ratio in the continuum of well exposed stellar spectra varies from 10 to about 15 depending on position in the spectral format. The co-addition of nine images can yield an improvement in S/N by factors of 2.3 to 2.9. Abundance determinations using such spectra have errors due to the uncertainties in the IUE data of order 0.2 dex.

Prior to the observing runs, we estimated the optimal large aperture high dispersion exposure times of Mu Leporis for SWP images to be 6 minutes at 1400Å, 3 minutes at 1700Å, and 1 minute at 1965Å and for LWP images to be 2.4 minutes at 2200Å, 1.3 minutes at 2400Å, and 0.7 minutes at 2740Å. Exposure times for Upsilon Herculis would generally be longer by a factor of about 4. During the actual observation runs, we found that these estimated exposure times were quite good and only a few minor adjustments were made during the runs.

Our strategy was to obtain a sufficient number of SWP and LWP exposures to obtain the equivalent of at least 3 properly exposed high dispersion images for the bulk of each camera's range. Thus for each star and camera combination we obtained a total of nine high dispersion exposures: for the three exposure levels, we will obtain exposures at three different offset positions in the large aperture. We alternated SWP and LWP exposures to use our time most efficiently. In all we got 10 SWP and 9 LWP high dispersion images of Mu Lep and 9 SWP and 8 LWP high dispersion images of Upsilon Her following the procedure described above. We also obtained a SWP and a LWP trailed exposure of Upsilon Herculis at low dispersions.

We had enough time left in the observing runs to take a first glance (1 high dispersion image and 1 trailed low dispersion exposure in each camera) at two lower priority stars, 10 Tri and Nu Cnc, which we plan to study further in upcoming projects.

The high dispersion images of Mu Lep and Upsilon Her were co-added by Dr. Adelman at The Citadel and then sent to me at SUNY Oswego via magnetic tape. Initial inspection of the co-added spectra showed that they were of excellent quality, comparable to the best of the co-added spectra obtained previously by Drs. David Leckrone (Goddard) and Adelman.

Visual comparison of the observed N I features in Mu Lep and Upsilon Her at 1742 and 1745Å with previous IUE observations analyzed by Roby, Leckrone, and Adelman (in preparation) of the Hg-Mn stars Kappa Cnc and Iota CrB show that N is also greatly deficient in the newly observed stars. The observations of Mu Lep and Upsilon Her hence doubles the number of Hg-Mn stars that have high quality co-added IUE spectra.

The basic methodology of our analysis is to calculate synthetic spectra using as input Adelman's optical abundances and ATLAS model atmospheres as well as Kurucz' atomic line data. The synthetic spectra are then compared with the co-added IUE observations. The comparison is used first to estimate the location of the local continuum (often a few

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percent above the actual observed spectrum peaks), and then to determine the abundance of individual line features by requiring a match between the computed and observed line profile. The match is obtained by varying the input abundance of the elemental species in question.

One task in the analysis of the data before us (roughly 2000Å of spectra for each star) was the accurate setting of the continuum. This problem has been addressed in the following manner. By judicious use of computer storage space at Oswego and resolution constraints imposed by the high dispersion observations, I was able to compute 500Å chunks of synthetic spectra for the program stars using the known optical abundances of the elements. A plotting routine was written so that the synthetic spectrum could be displayed in detail overlying the observed spectrum with a preliminary rough normalization. I modified the spectrum normalization routine, NORM, provided by Goddard's RDAF team so that up to 200 continuum points could be set across a single 500Å chunk of a co-added IUE spectrum. The NORM routine was also modified to allow scrolling in a "WIDGET" window, so that the 500Å of observed spectrum could be viewed 50Å at a time. This procedure made it possible to carefully set the detailed local continuum easily and efficiently across large chunks of observed spectrum.

The purchase of a DECstation 5000/200cx made possible by this grant and two others has greatly enhanced the procedure outlined above and also greatly reduced calculation and plotting times.

Continuum settings are currently being set for the entire data set. Detailed abundance analyses of the N I features at 1742, 1745, and 1411Å will proceed shortly. I will be meeting with Dr. Adelman in December to confer on this and other projects.

The N abundance results will be published together with those previously obtained for Kappa Cnc, Iota CrB, and four normal A stars by Roby, Leckrone, and Adelman. Analyses of other elements in these two stars are being incorporated into a larger project involving Drs. David Leckrone (Goddard), Charles Cowley (Univ. of Michigan), Glenn Wahlgren (Goddard) as well as Adelman and myself. The spectrophotometric modelling of the low dispersion trailed spectra we obtained will aslo be part of this program.

FINAL BUDGET SUMMARY FOR SUNY OSWEGO

ITEM	BUDGET
SALARY: 1 mo/summer at reduced rate '91	1,526
FRINGE BENEFITS (27% wages as of July 1, 1991)	412
TRAVEL	
FIRST IUE OBS. RUN	368
Oswego - Greenblet, MD - Oswego	
From 8am, Nov. 13, 1990 to 4pm, Nov. 17, 1990	
(Lodging was free - stayed with colleague)	
Per Diem (4 days @ \$26/day)	
Transportation - private car (1016 mi. @ 26¢/mi.)	
SECOND IUE OBS. RUN	385
Oswego - Greenbelt, MD - Oswego	
From 8pm, Jan. 9, 1991 to 8pm, Jan. 13, 1991	
(Lodging was free - stayed with colleague)	
Per Diem (4 days @ \$26/day)	
Transportation - private car (1023 miles @ 27.5¢/mi.)	
TRAVEL TOTAL =	753
COMPUTER Equip. and SOFTWARE	
DECstation 5000 pkg	2,843
(A DEC grant and a SUNY matching grant funded the remaining ~\$15,000 of this purchase)	
Insurance for DS5000	400
IDL Upgrade to DECstation	900
SUPPLIES, PHONE, OTHER	198
TOTAL Direct Costs	7,032
Indirect Costs (70% wages as of July 1)	1,068
TOTAL COSTS	8,100